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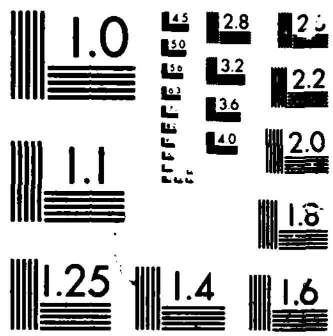
SCIENCE APPLICATIONS INTERNATIONAL CORP MCLEAN VA
J GOETZ ET AL 15 AUG 85 SAIC-85/1814 DNA-TR-84-405
UNCLASSIFIED DNA001-84-C-0351 F/G 6/18 NL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DNA-TR-84-405

NEUTRON EXPOSURE FOR DOD NUCLEAR TEST PERSONNEL

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15 August 1985

Technical Report

CONTRACT No. DNA 001-84-C-0351

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AD-A175839

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188 Exp. Date: Jun 30, 1986

1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY: N/A since Unclassified	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE: N/A since Unclassified	
4. PERFORMING ORGANIZATION REPORT NUMBER(S): SAIC-85/1814	5. MONITORING ORGANIZATION REPORT NUMBER(S): DNA-TR-84-405
6a. NAME OF PERFORMING ORGANIZATION: Science Applications International Corporation; 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION: Director Defense Nuclear Agency
6c. ADDRESS (City, State, and ZIP Code): P.O. Box 1303 McLean, VA 22102-1303	7b. ADDRESS (City, State, and ZIP Code): Washington, DC 20305-1000
8a. NAME OF FUNDING/SPONSORING ORGANIZATION; 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: DNA 001-84-C-0351
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
62715H	U99QMXM	H	DH008529

11. TITLE (Include Security Classification)
NEUTRON EXPOSURE FOR DOD NUCLEAR TEST PERSONNEL

12. PERSONAL AUTHOR(S)
Goetz, J., Klemm, J., Thomas, C., Weitz, R.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Technical	FROM 840615 TO 841215	850815	40

16. SUPPLEMENTARY NOTATION
This work was sponsored by the Defense Nuclear Agency under RDT&E RMSS Code B350084466 U99QMXMH00012 H2590D.

17. COSATI CODES

FIELD	GROUP	SUB-GROUP
18	3	
6	18	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Nuclear Test Personnel Review
Neutron Dose
Radiation Transport

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Neutron doses for DoD units/projects that participated in atmospheric nuclear test programs are assessed using computer codes ATR and ANISN. Units/projects whose personnel are identified as having received a neutron dose of at least 1 mrem are listed by operation and shot. Of the several thousand units/projects screened, 160 are identified as having received a free-field neutron exposure exceeding 1 mrem. Of these, approximately 75 percent are aircrews with the remainder being ground-based units, either scientific projects or military observer/maneuver units.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL: Betty L. Fox	22b. TELEPHONE (Include Area Code): (202) 325-7042; 22c. OFFICE SYMBOL: DNA/STTI

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

CONVERSION TABLE

Conversion factors for U.S. Customary to metric (SI) units of measurement

MULTIPLY ⟶ BY ⟶ TO GET
TO GET ⟵ BY ⟵ DIVIDE

angstrom	1.000 000 X E -10	meters (m)
atmosphere (normal)	1.013 25 X E +2	kilo pascal (kPa)
bar	1.000 000 X E +2	kilo pascal (kPa)
barn	1.000 000 X E -28	meter^2 (m^2)
British thermal unit (thermochemical)	1.054 350 X E +3	joule (J)
calorie (thermochemical)	4.184 000	joule (J)
cal (thermochemical)/cm^2	4.184 000 X E -2	mega joule/m^2 (MJ/m^2)
curie	3.700 000 X E +1	*giga becquerel (GBq)
degree (angle)	1.745 329 X E -2	radian (rad)
degree Fahrenheit	t_K = (t°f + 459.67)/1.8	degree kelvin (K)
electron volt	1.602 19 X E -19	joule (J)
erg	1.000 000 X E -7	joule (J)
erg/second	1.000 000 X E -7	watt (W)
foot	3.048 000 X E -1	meter (m)
foot-pound-force	1.355 818	joule (J)
gallon (U.S. liquid)	3.785 412 X E -3	meter^3 (m^3)
inch	2.540 000 X E -2	meter (m)
jerk	1.000 000 X E +9	joule (J)
joule/kilogram (J/kg) (radiation dose absorbed)	1.000 000	Gray (Gy)
kilotons	4.183	terajoules
kip (1000 lbf)	4.448 222 X E +3	newton (N)
kip/inch^2 (ksi)	6.894 757 X E +3	kilo pascal (kPa)
ktap	1.000 000 X E +2	newton-second/m^2 (N-s/m^2)
micron	1.000 000 X E -6	meter (m)
mil	2.540 000 X E -5	meter (m)
mile (international)	1.609 344 X E +3	meter (m)
ounce	2.834 952 X E -2	kilogram (kg)
pound-force (lbs avoirdupois)	4.448 222	newton (N)
pound-force inch	1.129 848 X E -1	newton-meter (N·m)
pound-force/inch	1.751 268 X E +2	newton/meter (N/m)
pound-force/foot^2	4.788 026 X E -2	kilo pascal (kPa)
pound-force/inch^2 (psi)	6.894 757	kilo pascal (kPa)
pound-mass (lbm avoirdupois)	4.535 924 X E -1	kilogram (kg)
pound-mass-foot^2 (moment of inertia)	4.214 011 X E -2	kilogram-meter^2 (kg·m^2)
pound-mass/foot^3	1.601 846 X E +1	kilogram/meter^3 (kg/m^3)
rad (radiation dose absorbed)	1.000 000 X E -2	**Gray (Gy)
roentgen	2.579 760 X E -4	coulomb/kilogram (C/kg)
shake	1.000 000 X E -8	second (s)
slug	1.459 390 X E +1	kilogram (kg)
torr (mm Hg, 0° C)	1.333 22 X E -1	kilo pascal (kPa)

*The becquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s
**The Gray (Gy) is the SI unit of absorbed radiation.

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SECTION 1
INTRODUCTION AND SUMMARY

A method is developed that allows each participating project or unit in the US atmospheric nuclear testing program to be rapidly screened to determine whether exposure to neutron radiation contributed significantly to an individual's total dose. The most important parameters required are the neutron environment generated by a particular detonation and the participant's distance from the detonation. Knowledge of other factors such as personnel posture at the time of detonation (e.g., standing in the open, crouched in a trench, or in an aircraft) permit refinements to be made to the calculated free-field exposure. For the purpose of this report, a neutron dose of one millirem is selected as the threshold and 1-mrem isodose contours (envelopes) are constructed. The envelopes, established as a function of weapon type, yield, height-of-burst, and atmospheric conditions determine the distance from a particular detonation for a free-field neutron dose of 1 mrem. The distance a participating unit or project was from the detonation, as obtained from the various source documents, is superimposed on the appropriate envelope; if the distance falls outside the 1-mrem isodose contour, the unit is excluded from further analysis, i.e., it received a neutron dose of less than 1 mrem. However, if the distance falls within the 1-mrem envelope, the unit is identified in this report as having possibly received a neutron dose of at least 1 mrem (neglecting shielding). Details on the construction of the 1-mrem dose envelopes for continental and oceanic nuclear tests are found in Section 2. Those projects/units identified as having received a neutron dose of 1 mrem or greater are tabulated in Section 3. Of the several thousand units/projects screened, 160 are identified as having received a free-field neutron exposure exceeding 1 mrem. Of these, approximately 75 percent are aircrews with the remainder being ground-based units, either scientific projects or military observer/maneuver units.

SECTION 2
ISODOSE CONTOURS

2.1 CONTINENTAL ISODOSE CONTOURS .

Calculations are performed using Version 4 of the computer code ATR (Air Transport of Radiation) to characterize the neutron component of the radiation environment in the airspace surrounding the low yield nuclear detonations (1-80 KT) at NTS. ATR4 is a radiation environment prediction code that uses an extensive data base developed from detailed radiation transport calculations with computer codes ANISN and DOT. The use of these codes is described in Reference 1. Two specific cases are analyzed to bound the range of possible results.

(1) Operation RANGER - Shot EASY. This shot is selected as representing the best-case scenario. The ATR neutron source spectrum used is that of a pure fission device, typical of the earlier weapons. The mean air density between the surface and the burst height (330 meters) is 1.18×10^{-3} g/cm^3, a very high value for the Nevada shots. The high air density, and its corresponding neutron attenuation, results in a lower neutron dose at a given range.

(2) Operation PLUMBBOB - Shot HOOD. This shot is selected as representing the worst-case scenario. The ATR neutron source spectrum used is that of a boosted fission device, typical of the later weapons. The mean air density between the surface and burst height (460 meters) is 0.992×10^{-3} g/cm^3, the lowest of any low-altitude Nevada detonation. The low air density, coupled with the enhanced neutron output, results in a higher neutron dose at a given range.

In each case, an ATR calculation is made to determine neutron dose in rads (tissue) as a function of horizontal range along the surface, and as a function of slant range along radials from the burst point at angles of 30, 60, and 90 degrees to the horizontal. The mean air density between the surface and the burst point is used as a

reference point in the ATR atmospheric density gradient model to then determine the appropriate atmospheric density between the burst point and all other points of interest. The resulting neutron dose data are scaled linearly with yield to determine the neutron environment of similar detonations having different yields. Neutron rads are converted to rem using an effective quality factor of 13 for the energy spectrum of the neutrons emitted, as developed in Reference 2. Distances from the burst point along the surface and along the various radials to the 1-mrem dose equivalent level are determined and 1-mrem contours (envelopes) are constructed for each of six weapon yields. The contours shown in Figure 1 represent best and worst case conditions for neutron transport (Cases (1) and (2) above). The effect of decreasing air density with altitude is easily seen in the figures as the 1-mrem contours extend to greater distances above the burst point than along the surface radial.

2.2 OCEANIC ISODOSE CONTOURS.

For surface bursts conducted during the oceanic testing, calculations were performed with a multigroup one-dimensional discrete ordinates transport code (ANISN) to characterize the neutron component of the radiation environment in the airspace surrounding nuclear detonations at the Pacific Proving Grounds (PPG). The ANISN transport code allows for selective source spectra and transport media composition. For the present analysis, neutrons are transported from a point source in spherical geometry. Two sources are used:

(1) A fission source, specifically that of the Nagasaki device (Fat Man), taken from the DNA Weapon Output Handbook. This source is similar to most of the early fission devices detonated at PPG.

(2) A thermonuclear source, taken from D.E. Bartine, et al., "Production and Testing of the DNA Few-Group Coupled Neutron-Gamma Cross-Section Library," ORNL/TM-4840, March 1977. This source is representative of the medium-to-large yield thermonuclear devices detonated at the PPG.

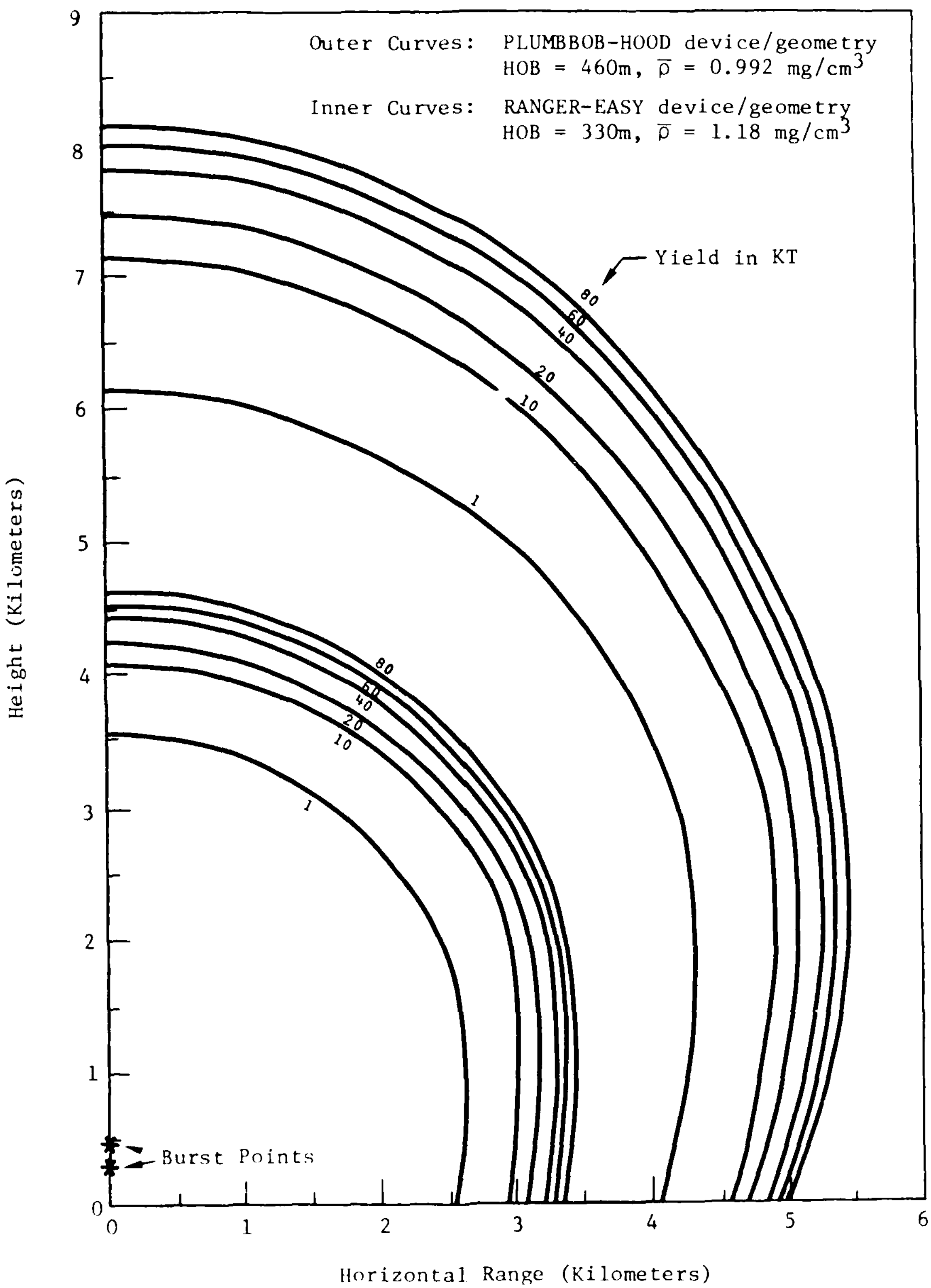

Figure 1. Neutron isodose (1 mrem) contours for continental detonations.

The atmosphere is assumed to be standard, with a density variation with altitude and an altitude-dependent moisture content derived from data given in DNA 4102T, "A Low Altitude Meteorological Data Base." The specific moisture content used in this analysis corresponds to that of Enewetak/Bikini during the winter (dry) period. For purposes of radiation transport calculations, the atmosphere is modeled as five homogeneous layers, with properties derived by averaging over each layer thickness. This atmosphere model is detailed as follows:

Region	Altitude (km)	Avg Dry Air Density (g/cm^3)	Avg Moisture Content ($g\ H_2O/g$ dry air)
I	0 - 2	1.11×10^{-3}	8.0×10^{-3}
II	2 - 4	9.10×10^{-4}	3.4×10^{-3}
III	4 - 6	7.37×10^{-4}	1.2×10^{-3}
IV	6 - 8	6.00×10^{-4}	6.0×10^{-4}
V	8 - 10	4.66×10^{-4}	4.0×10^{-4}

ANISN calculations are made to determine neutron dose in rads (tissue) per source neutron as a function of range along radials from the burst point. Calculations are performed at angles of 30°, 60°, and 90° up from the horizontal. Calculations were not made along the surface since the one-dimensional ANISN results do not include the perturbing effects of the air-sea interface. Much more extensive 2-D calculations are required to accurately define the neutron dose as a function of range in this region. The properties of the transport medium are derived from the 5-layer model, with the thickness of each layer scaled as the reciprocal of the sine of the angle the radial makes with the horizontal; for example, at 30° from the horizontal, layer thickness = 2 km/sin 30°.

Normalized ANISN output, in rads (tissue) per source neutron, are converted to rem by assuming a neutron output of 2.0×10^{23} neutrons/KT (a representative value for these weapon types) and an effective neutron quality factor of 13. These values are then used to construct 1-mrem contours for various weapon yields for each of the two weapon types. The results are shown in Figure 2. Although not drawn to sea

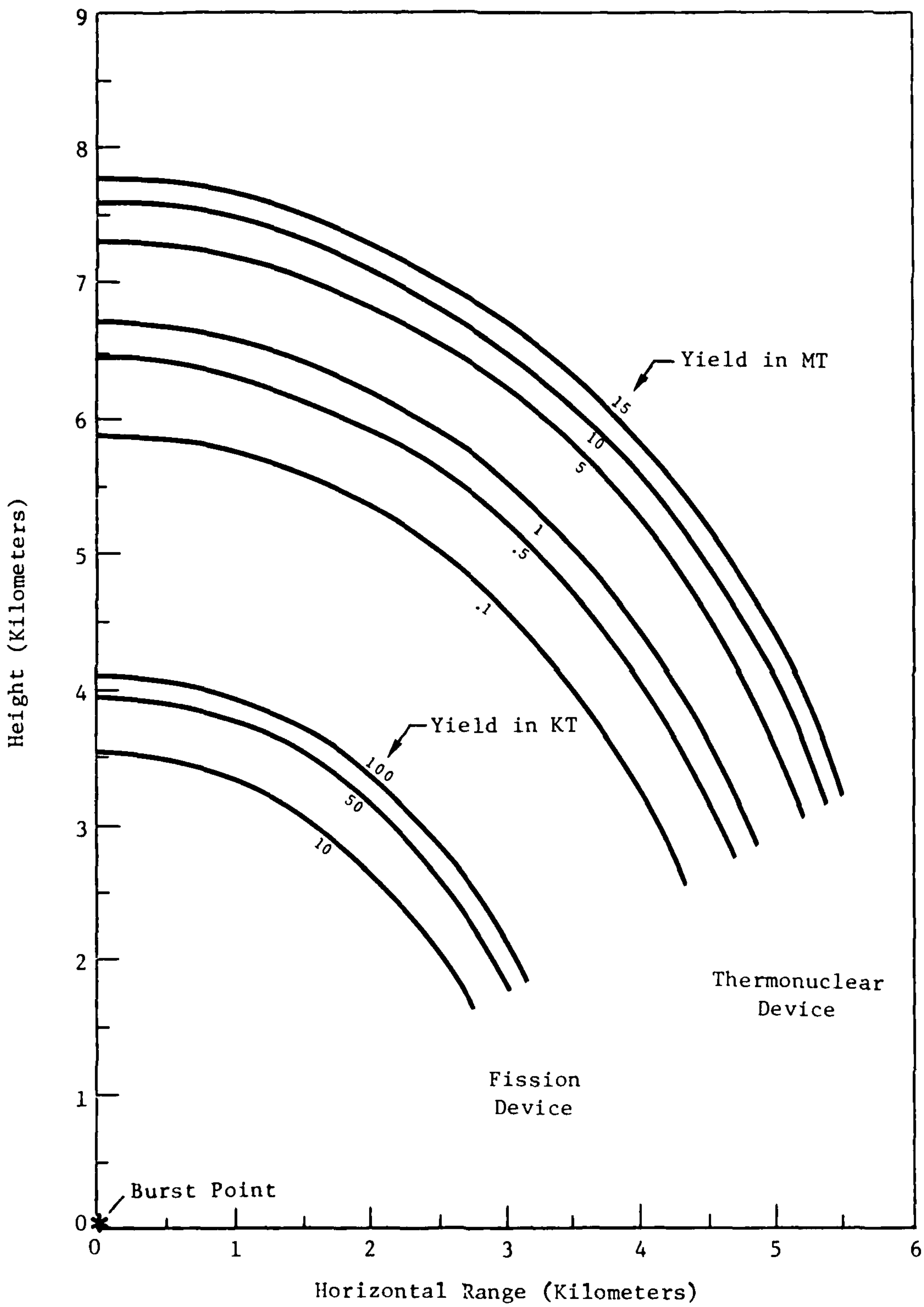

Figure 2. Neutron isodose (1 mrem) contours for oceanic detonations - surface bursts.

level, the isodose contours would tend to bend inward toward surface zero if 2-D transport calculations were performed to define the neutron environment in this region.

For the airbursts conducted during the oceanic testing, calculations were performed using ATR4 to characterize the neutron environment. Since ATR4 does not consider the effect of moisture in the air on neutron transport, the 1-mrem isodose envelopes thus constructed tend to be high-sided in estimating the slant range to 1 mrem, i.e., calculated slant ranges using ATR4 are greater than the actual slant ranges to 1 mrem. Four combinations of weapon yield and height-of-burst were used to construct the isodose curves in Figure 3:

(1) A 100KT (0.8 fission fraction) source at a height-of-burst of 1.0 km
(2) A 500KT (0.8 fission fraction) source at a height-of-burst of 1.5 km
(3) A 1MT thermonuclear source at a height-of-burst of 2.7 km
(4) A 10MT thermonuclear source at a height-of-burst of 3.5 km

These particular combinations of yield and height-of-burst typify the many airdropped weapons detonated during the oceanic testing, especially during Operation DOMINIC I. When the contours in Figure 3 are compared to the 1-mrem contours in Figure 2 for surface bursts, the effect of decreased air density (and atmospheric moisture) at the higher heights-of-burst on neutron transport is clearly evident by the much greater distances to 1-mrem.

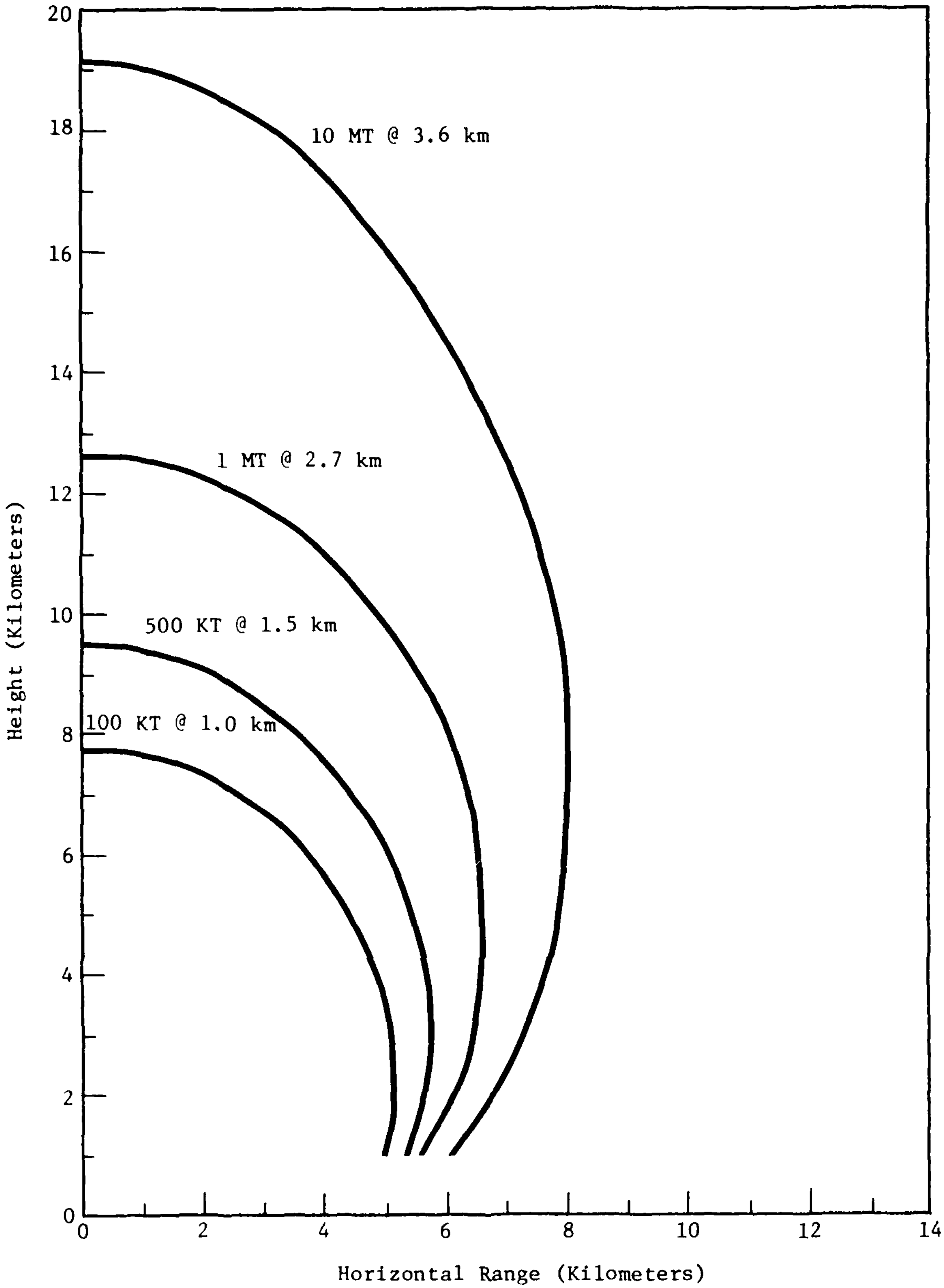

Figure 3. Neutron isodose (1 mrem) contours for oceanic detonations - air bursts.

SECTION 3
DOD PERSONNEL RECEIVING NEUTRON DOSES

3.1 CONTINENTAL OPERATIONS.

DoD personnel participating at Nevada tests witnessed shots from several locations. Most were at News Nob near the Control Point (approximately 10 kilometers from the closest shot) and far enough from any shot to be out of range of significant initial effects, including neutron exposure. However, many troops who participated in the Desert Rock exercises observed a shot from a closer distance, generally from 2.5 to 5 kilometers from the burst, depending on the yield. These troops were normally in trenches, but some were in armored vehicles or even in the open. In some cases, volunteer observers (whose identities are all known) were positioned in trenches slightly more than 1.8 kilometers from the burst.

Aircraft were normally located at sufficient distances from a detonation to avoid any detrimental blast effect. There were cases where delivery (and simulated delivery) aircraft were close enough at the time of burst for the crew to have received a neutron dose. Other aircraft, such as those in aircraft structures tests, were also close enough to receive a neutron dose on several occasions.

Neutron doses are calculated for most DoD observers and maneuver troops who participated at the continental detonations (e.g., Reference 1). The results of these calculations, which consider the shielding provided by trenches and armored vehicles, are tabulated in this report for those participants who received a neutron dose of 1 mrem or more. The isodose contours shown in Figure 1 are used to identify other projects, units, and aircrews whose activities resulted in possible neutron exposures. These units, and the specific operations/shots at which they participated, are identified in this report for subsequent determination of their neutron dose.

Some DoD personnel received neutron doses of 1 mrem or greater in seven of the eight atmospheric test operations conducted in Nevada. At TRINITY (in New Mexico) and Operation RANGER, none of the units/projects involved received neutron doses

exceeding 1 mrem. Those in the remaining seven operations that received neutron doses of 1 mrem or more are tabulated in Tables 1 through 7. If a unit/project is not listed, this indicates a neutron exposure of less than 1 mrem. If a neutron dose has previously been reconstructed for a particular unit, the calculated dose is given. An "X" in the table indicates a possible neutron dose of 1 mrem or greater that should be verified through subsequent dose reconstructions.

Table 1. DoD personnel receiving a neutron dose at Operation BUSTER-JANGLE.

	Neutron Dose (rem) at Shot					
PARTICIPANTS	BAKER	CHARLIE	DOG	EASY	SUGAR	UNCLE
Weapon Delivery Aircrew	X	X	X	X		
Project 4.1 Aircrew					0.026	
Project 6.5 Aircrew			X	X		
Project 8.4 Photographers (On Project 6.5 Aircraft)			X	X		

Table 2. DoD personnel receiving a neutron dose at Operation TUMBLER-SNAPPER.

	Neutron Dose (rem) at Shot					
PARTICIPANTS	BAKER	CHARLIE	DOG	EASY	FOX	HOW
Weapon Delivery Aircrew	X	X	X			
Project 1.1 Aircrew				X		X
Project 6.4 Aircrew	X	X	X		X	

"X" indicates a possible neutron dose of 1 mrem or greater which will be verified through subsequent dose calculations.

Table 3. DoD personnel receiving a neutron dose at Operation UPSHOT-KNOTHOLE.

PARTICIPANTS	Neutron Dose (rem) at Shot								
	ANNIE	NANCY	DIXIE	BADGER	SIMON	ENCORE	HARRY	GRABLE	CLIMAX
Observers	0.018				.003				
Volunteer Observers		0.63		2.4	28				
Battalion Combat Teams A&B	0.018				.003				
Weapon Delivery Aircrew			X			X			X
Project 1.3 Aircrew and Ground Personnel			X X			X			
Project 4.1 Aircrew			X			X			
Project 5.1 Aircrew	X	X		X	X	X	X		
Project 5.2 Aircrew			X			X			
Project 5.3 Aircrew						X			
Project 6.2 Aircrew			X			X			
Project 6.3 Aircrew			X	X	X	X	X		
Project 6.11 Aircrew			X			X			

"X" indicates a possible neutron dose of 1 mrem or greater which will be verified through subsequent dose calculations.

Table 4. DoD personnel receiving a neutron dose at Operation TEAPOT.

	Neutron Dose (rem) at Shot										
PARTICIPANTS	WASP	MOTH	TESLA	TURK	HORNET	BEE	APL-1	WASP PRIME	HA	MET	APL-2
Observers		0.16	1.4			0.01	0.029				.063
Maneuver Troops						0.01					
Volunteer Observers											4.5
Task Force RAZOR											
Co. "A", 723rd Tank Bn.											0.39
Co. "C", 723rd Tank Bn.											0.14
Tank Command Gp.											0.27
Co. "B", 723rd Tank Bn.											0.013
Armored Inf. Plt. (Rt)											0.031
Armored Inf. Plt. (Left)											0.004
Armored Inf. Plt. (Ctr)											0.010
Staff Element											0.021

Table 4. DoD personnel receiving a neutron dose at Operation TEAPOT (Concluded).

	Neutron Dose (rem) at Shot										
PARTICIPANTS	WASP	MOTH	TESLA	TURK	HORNET	BEE	APL-1	WASP PRIME	HA	MET	APL-2
Weapon Delivery Aircrew	X							X	X		
Project 1.2 Aircrew									X		
Project 5.1 Aircrew						X				X	
Project 5.2 Aircrews				0.024*	X	1.4*	0.007			X	
Project 6.4 Aircrew									X		
Project 8.1 Aircrews						0.15*	0.002			X	0.039*
Project 8.4a Personnel (On Delivery Aircraft)									X		
Project 9.1 Aircrew									X		
Project 40.3 Aircrew		X	X								
Project 40.4 Aircrew				0.002							
Project 40.12 Aircrew					X						

* Applies to closest aircraft. Other aircraft received less than 0.001 rem.

"X" indicates a possible neutron dose of 1 mrem or greater which will be verified through subsequent dose calculations.

Table 5. DoD personnel receiving a neutron dose at Operation PLUMBBOB.

Neutron Dose (rem) at Shot

PARTICIPANTS	BLTZMN	WLSN	PRSCLA	HOOD	DIABLO	JOHN	KEPLER	STOKES	SHASTA	DPLR	FRNKLN PRIME	SMOKY	GALILEO
Observers			0.002		0.001*		0.012*			0.133			
Volunteer Observers						0.007							
Task Force BIG BANG													0.010
Task Force WARRIOR										.227			
Weapon Delivery and Alternate Aircrew						16.5 1.0							
Project 5.1 Aircrew	X	X	0.010		X			X					
Project 5.3 Aircrews	X			2.9 4.9**	X					X		X	
Project 5.4 Aircrew	X		1.76	5.32	X				X	X		X	
Project 5.5 Aircrew	X			0.081		16.5		X		X	X		
Project 6.5							X						
Project 50.8							X						

*Estimate based on assumed scenarios for similar yields and heights-of-burst
**Applies to closest aircraft

"X" indicates a possible neutron dose of 1 mrem or greater which will be verified through subsequent dose calculations.

Table 6. DoD personnel receiving a neutron dose at Operation HARDTACK II.

PARTICIPANTS	Neutron Dose (rem) at Shot QUAY	HMLTN	R-ARRIBA	HMBLT
Project 4.3		X		
Project 8.8	X	X	X	X
1352nd Motion Picture Squadron		X		

Table 7. DoD personnel receiving a neutron dose at Operation DOMINIC II.

PARTICIPANTS	Neutron Dose (rem) at Shot LTL FLR2	JNIE BOY	SMALL BOY	LTL FLR1
IVY FLATS Maneuver Troops				X
IVY FLATS Military Observers				X
Project 7.12			X	
Project 7.13 Aircrew			X	
Project 7.15 Aircrew			X	
Project 7.16 Aircrew	X		X	
Project 8.1				0.001
Project 9.2	X	X	X	0.50

"X" indicates a possible neutron dose of 1 mrem or greater which will be verified through subsequent dose calculations.

3.2 OCEANIC OPERATIONS.

Most of the nuclear test operations conducted in the Pacific were held at either Bikini or Enewetak Atolls. DoD participants (except aircrews) at Operations CROSSROADS (1946), SANDSTONE (1948), GREENHOUSE (1951), IVY (1952), CASTLE (1954), REDWING (1956), and HARDTACK I (1958), observed the detonations in the open either from ships or from residence islands on the atolls, well removed (at least 12 kilometers) from any of the shots. It is evident from Figure 2 that no one observing the tests from these locations received a neutron dose of 1 mrem or more. Operation WIGWAM (1955), an underwater detonation approximately 800 kilometers southwest of San Diego, and Operation ARGUS (1958), a series of three high-altitude tests conducted in the South Atlantic, did not result in any participant receiving a neutron dose. During Operations HARDTACK I and DOMINIC I (1962), rocket launched weapons were detonated directly over Johnston Island, but at altitudes (> 18 kilometers) precluding any neutron exposure to island-based personnel and participating shipboard units. The many airdropped weapons at DOMINIC I were detonated either 16-32 kilometers south of Christmas Island or 400-600 kilometers from Johnston Island; the closest ships to any of the airdrops were at least 16 kilometers from surface zero (at anchor off Christmas Island), again precluding the possibility of island-based or shipboard personnel receiving a neutron exposure. Another test during Operation DOMINIC I, a low-yield underwater burst, was conducted 680 kilometers southwest of San Diego, California. There was no neutron dose for any participant.

As in the continental test operations, aircraft were normally positioned at sufficient distances from the detonation to avoid damaging blast effects. There were, however, instances during the oceanic testing where test aircraft were within range of a neutron dose. The isodose contours in Figure 2 are used to identify those aircrews whose activities resulted in possible neutron exposures from the many surface detonations conducted during the oceanic testing. The isodose contours in Figure 3 are used primarily for the B-52 crews who delivered the weapons that were dropped during Operation DOMINIC I; they are also used in conjunction with the airdrops at Operations CROSSROADS (ABLE), IVY (KING), and REDWING (CHEROKEE and

OSAGE). Of the twenty-nine airdrops conducted during Operation DOMINIC I, the slant range between the drop aircraft (the closest aircraft) and the detonation are known for ten of the tests. While participating in these ten tests, the drop aircraft remained well outside (at least 4 kilometers) of the 1-mrem contours determined for each of the yields and heights-of-burst. It is assumed that similar operational procedures were followed for the remaining nineteen detonations for which the slant ranges are not known, and that the aircrews participating at these tests were not exposed to neutron radiation.

Only two of the ten operations conducted in oceanic areas resulted in participants receiving a neutron dose of 1 mrem or greater. The project personnel identified as having received neutron exposures at Operations REDWING and HARDTACK I are tabulated in Table 8 and Table 9, respectively.

Table 8. DoD personnel receiving a neutron dose at Operation REDWING.

PARTICIPANTS	Neutron Dose (rem) at Shot							
	LACROSSE	ERIE	FLTHEAD	KICKAPOO	INCA	DAKOTA	MOHAWK	HURON
Project 5.3 Aircrew						X		X
Project 5.4 Aircrew		X			X			
Project 5.5 Aircrew						X	X	
Project 5.6 Aircrew	X			X	X			
Project 5.8 Aircrew			X					X

"X" indicates a possible neutron dose of 1 mrem or greater which will be verified through subsequent dose calculations.

Table 9. DoD personnel receiving a neutron dose at Operation HARDTACK I

	Neutron Dose (rem) at Shot					
PARTICIPANTS	CACTUS	BTRNUT	KOA	MAGNOLIA	TOBACCO	WALNUT
Project 5.2 Aircrew	0.105*	X	X	0.030*	0.020**	0.015*
Project 5.3 Aircrew	0.135*					X

* Doses based on sulfur packet measurements

** Aircraft position falls outside 1 mrem contour

"X" indicates a possible neutron dose of 1 mrem or greater which will be verified through subsequent dose calculations.

SECTION 4
CONCLUSIONS

Military units and scientific projects that participated in the US atmospheric nuclear testing program were screened to determine if exposure to neutron radiation was a significant contributor to an individual's total dose. Of all the projects/units screened, 160 are identified as receiving a probable neutron dose of 1 mrem or more. Of these, approximately 75 percent are aircrews with the remainder being ground-based units (either scientific projects or military observer/maneuver units). Neutron dose calculations have previously been performed (e.g., References 3 and 4) for all military observer and maneuver troops except those identified in this report as being participants in the IVY FLATS troop exercises at Operation DOMINIC II. Neutron dose calculations are to be performed for personnel assigned to eight scientific projects fielded during Operations PLUMBBOB (2 projects), HARDTACK II (3 projects), and DOMINIC II (3 projects). Likewise, neutron doses are to be quantified for the aircrews identified in this report as having a potential neutron dose of 1 mrem or more. The projects/units identified in this report are those for which neutron doses have been previously calculated or that received a free-field neutron dose of at least 1 mrem. Subsequent detailed dose calculations, which will include the effect of shielding, will likely decrease the number of projects/units that actually received a neutron exposure exceeding 1 mrem.

SECTION 5
LIST OF REFERENCES

1. "Analysis of Radiation Exposure for Troop Observers, Exercise Desert Rock V, Operation UPSHOT-KNOTHOLE," DNA 5742F, Defense Nuclear Agency, 28 April 1981. AD/A 116 921.*

2. "Analysis of Radiation Exposure for Task Force WARRIOR, Shot SMOKY, Exercise Desert Rock VII-VIII, Operation PLUMBBOB," DNA 4747F, Defense Nuclear Agency, 31 May 1979. AD/A 070 239.*

3. "Analysis of Radiation Exposure for Task Force BIG BANG, Shot GALILEO, Exercise Desert Rock VII-VIII, Operation PLUMBBOB," DNA 4772F, Defense Nuclear Agency, 9 April 1980. AD/A 085 801.*

4. "Analysis of Radiation Exposure for Troop Observers, Exercise Desert Rock VI, Operation TEAPOT," DNA 5354F, Defense Nuclear Agency, 15 July 1980. AD/A 121 701.*

*Available from:	National Technical Information Service 5285 Port Royal Road Springfield, VA 22161	Phone: (703) 487-4650
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